Insertions

(A) In his [1974] Zahar rephrases his definition in terms of a notion of empirical non-ad hocness expressed as a three-place relation between an observation statement, a theory, and a heuristic. See also in this connection the very clear account of empirical support ~~by~~ given by Worrall in his [1975]. However this more recent work has somewhat obscured the important distinctions drawn by Zahar in his [1973].

(B) Van Dyck et al. ([1977]).

(C) Naturally this <u>second</u> aspect of commitment cannot be assessed ~~a~~ via novel predictions within the current experimental domain.

P.T.O.

D Van Dyck, Jr., R.S., Schwinberg, P.B. and Dehmelt, H.G. [1977]: 'Precise Measurements of Axial, Magnetron, Cyclotron, and Spin-Cyclotron-Beat Frequencies on an Isolated 1-MeV Electron.' Physical Review Letters, 38, pp. 310-314.

E Worrall, J. [1975]: 'The Ways in which the Methodology of Scientific Research Programmes improves on Popper's Methodology', in Workshop No. 1 - Position Paper presented at the ~~#~~ Kronberg Conference.

F Zahar, E.G. [1974]: 'Einstein's Debt to Lorentz: A Reply to Feyerabend and Miller.' Paper presented at the Nafplion Conference, forthcoming in the British Journal for the Philosophy of Science.

3. Quantitative Predictions

We can apply this analysis to the important case of quantitative predictions.[4] Suppose a theory T predicts correctly an experimental result which is known to an accuracy of n significant figures. We assume as part of our background knowledge that the order of magnitude of the result is known, i.e we disregard the prediction of zeros occuring before or after the significant figures in the experimental result. As a concrete illustration we cite the theoretical predictions by quantum electrodynamics of the anomaly in the hydrogen spectrum known as the Lamb shift and the anomaly in the magnetic moment of the electron. For example the latter is now known experimentally to be ~~0.001159656.7 ± 3.5~~ $(11596524 \pm 2) \times 10^{-10}$ Bohr magnetons[5] whereas the theoretical prediction is ~~0.001159652.4 ± 0.6~~ $(11596524 \pm 6) \times 10^{-10}$ Bohr magnetons.[6] We thus have remarkable agreement to ~~six~~ seven significant figures. Clearly if we regard the prediction of each significant figure as an independent event then the appropriate value to take for ε is 0.1 since a false theory would have ten equal possibilities for filling in each digit. The question of what value to take for x is somewhat arbitrary. In agreement with Schaffner we do not follow a purely logical approach and set x = 0. For our purpose x reflects the scientist's confidence in the new theory T. One could argue that a scientist would not spend great efforts developing the consequences of a theory he did not believe in. By analogy with the situation in the Bayesian analysis of significance testing (see for example Redhead ([1974])) we could take $x = \frac{1}{2}$. Perhaps more realistically we should take x around 0.01 and adapt the sociological rule that unless a scientist has a one per cent level of confidence in the truth of his theory he would not seriously investigate it[7]. With this choice of parameters we see that the build-up of confidence in a theory which makes correct quantitative predictions, as the accuracy of the

experiment increases, would be illustrated by the graph for p_n in the figure.[8] Of course $p(e_{n+1})$ is only given by our analysis so long as other factors which could potentially influence the results are known not to be significant. For a certain value of n this condition will fail. For example in the case of the anomalous magnetic moment of the electron the effect of hadronic couplings introduce theoretical uncertainties which would ultimately make the prediction of the theory unreliable.[9]

4. Conclusion

The concept of a novel prediction plays a very important part in the way scientists assess their confidence in theories. Of course on a purely instrumentalist view of theories the question of novelty in Zahar's sense is of no consequence. But to a realist it is only in virtue of novel successful predictions that commitment to a theory can find rational justification. Our analysis has shown how the logic of comparative theory evaluation can be viewed if degrees of commitment are governed by Bayesian rationality constraints.

FOOTNOTES

1. Zahar [1973] p.101. Insertion (A)

2. Zahar [1973] p.103.

3. What we have shown is that $\mathcal{E} = 1$ is a necessary condition for T to be an ad hoc_2 explanation of e. To justify $\mathcal{E} = 1$ as a sufficient condition we must invoke a principle of insufficient reason, viz. if there is no reason for the community of scientists to entertain with non-vanishing prior probability only theories which explain e, then they will not so constrain their choice of alternative theories

4. The successful detailed quantitative predictions of a theory in respect of phenomena quite different from those which the theory was originally proposed to deal with has always attracted the attention of scientists. To take an example at random, in referring to his early work on the ground-state of Helium Hylleraas comments in his [1963] (p.42) "The end result of my calculations was...greatly admired and thought of as almost a proof of the validity of wave mechanics...in the strict numerical sense".

5. Insertion (B)

6. See value quoted in Calmet et al.([1977]). For a good account of the fluctuating agreement between theory and experiment the reviews by Lautrup, Peterman and de Raphael ([1972]) or Rich and Wesley ([1972]) may be consulted.

7. We may refer to Shimony's concept of commitment to a theory (see his [1970] pp.94-95). ~~is what we have in mind.~~ The degree of commitment measures the scientist's belief that the theory T belongs to the equivalence class of all theories which give the same true observational predictions within its domain of current experimentation and that the "true" theory "generalizes" in some sense the concepts embodied in T. Commitment measures our belief, not that a theory is true, but that it points the way to the truth. Insertion (C)

8. It is easy to see that our confidence in a theory at a given level of accuracy for agreement between theory and experiment does not depend on the particular scale of notation used to express the result.

9. According to Rich and Wesley ([1972]) the known hadronic contribution to the electron anomaly would affect the tenth significant figure.

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Insertions D and E →

Zahar, E.G. [1973] : 'Why did Einstein's Programme supersede Lorentz's?' The British Journal for the Philosophy of Science, 24, pp.95-123 and 223-262.

Insertion F →

20th July 1977

Dear John

I enclose 3 copies of a paper on the Logic of Comparative Theory Evaluation, for possible publication in the BJPS.

With best wishes,

Yours sincerely,

M. Redhead.

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